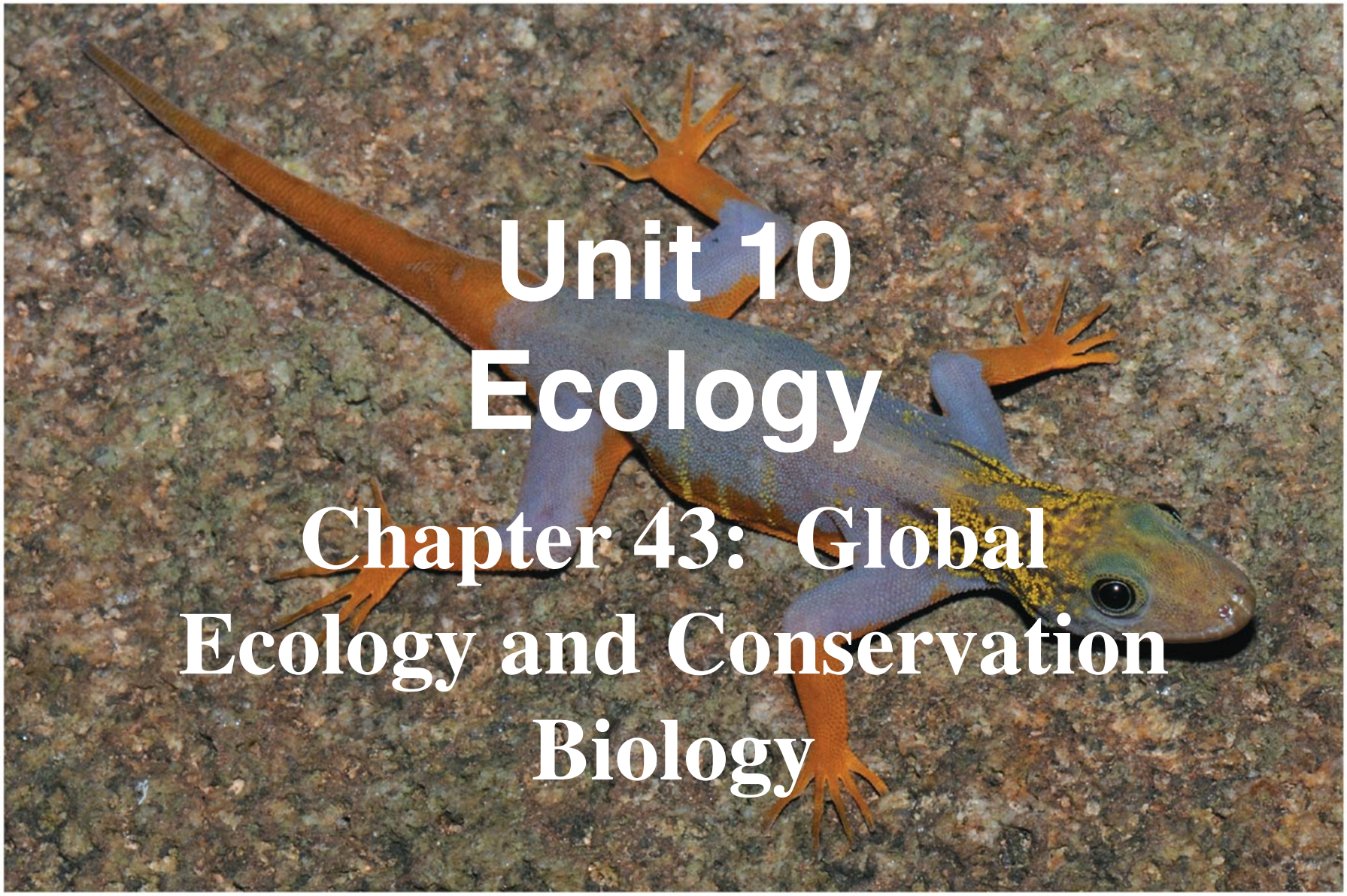


# Unit 10
# Ecology

## Chapter 43: Global Ecology and Conservation Biology

# Overview: Psychedelic Treasure

- Human activities are altering trophic structures, energy flow, chemical cycling, and natural disturbance
  - Tropical forests contain some of the greatest concentrations of species and are being destroyed at an alarming rate
  - Humans are rapidly pushing many species toward extinction

- **Conservation biology** seeks to preserve life and conserve biological diversity
  - Integrates several fields
    - Ecology
    - Evolutionary biology
    - Molecular biology
    - Genetics
    - Physiology

# Concept 43.1: Human activities threaten Earth's biodiversity

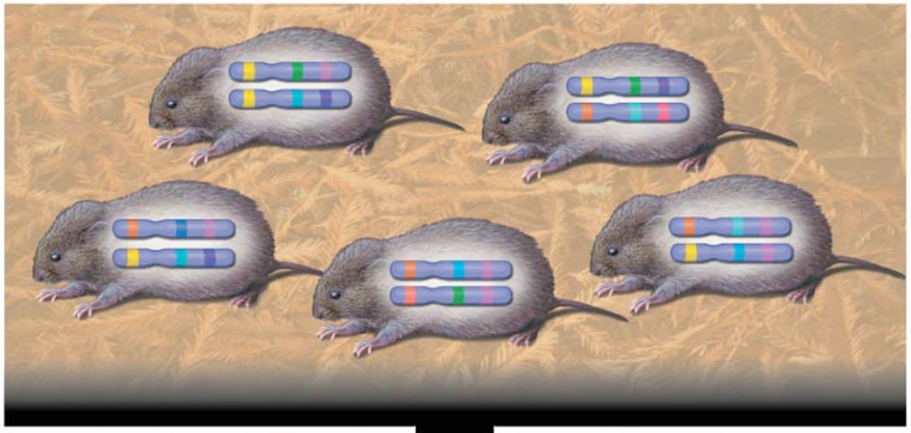
- Extinction is a natural process
  - But the high *rate* of extinction is responsible for today's biodiversity crisis
- Human activities are threatening Earth's biodiversity

# Three Levels of Biodiversity

- Biodiversity has three main components
  - Genetic diversity
  - Species diversity
  - Ecosystem diversity

Figure 43.3-3

**Genetic diversity in a vole population**



**Species diversity in a coastal redwood ecosystem**

**Community and ecosystem diversity across the landscape of an entire region**

# *Genetic Diversity*

- Genetic diversity comprises genetic variation within a population and between populations
- Population extinctions reduce genetic diversity
  - In turn reduces the adaptive potential of a species

# *Species Diversity*

- Species diversity is the variety of species in an ecosystem or throughout the biosphere
- According to the U.S. Endangered Species Act
  - An **endangered species** is "in danger of becoming extinct throughout all or a significant portion of its range"
  - A **threatened species** is likely to become endangered in the near future

# *Ecosystem Diversity*

- Human activity is reducing ecosystem diversity, the variety of ecosystems in the biosphere
- The local extinction of one species can have a negative impact on other species in an ecosystem
  - Ex: Flying foxes (bats) are important pollinators and seed dispersers

- More than 50% of wetlands in the United States have been drained and converted to agricultural or other use

- Streamside communities have been affected by
  - Overgrazing
  - Flood control
  - Water diversions
  - Lowering of water tables
  - Invasion by non-native plants

# Biodiversity and Human Welfare

- “We must consider our planet to be on loan from our children, rather than being a gift from our ancestors.”
- Species diversity also brings humans practical benefits

# *Benefits of Species and Genetic Diversity*

- Many species that are threatened could potentially provide
  - Medicine
  - Food
  - Fibers
- The loss of species also means loss of unique genes and genetic diversity
  - May code for useful proteins
- Thus biodiversity is a crucial natural resource!

# *Ecosystem Services*

- **Ecosystem services** encompass all the processes through which natural ecosystems help sustain human life
- Some examples of ecosystem services
  - Purification of air and water
  - Detoxification and decomposition of wastes
  - Reduction of impacts of extreme weather/flooding
  - Crop pollination, pest control, and soil preservation

# Threats to Biodiversity

- Most species loss can be traced to four major threats
  - Habitat loss
  - Introduced species
  - Overharvesting
  - Global change

# *Habitat Loss*

- Human alteration of habitat is the greatest threat to biodiversity throughout the biosphere
  - Due to agriculture, urban development, forestry, mining, pollution
- In almost all cases, habitat fragmentation and destruction lead to loss of biodiversity

# *Introduced Species*

- **Introduced species** are those that humans move from native locations to new geographic regions
  - Also called exotic species
  - Intentional or accidental
- Without their native predators, parasites, and pathogens, introduced species may spread rapidly
- Introduced species that gain a foothold in a new habitat usually disrupt their adopted community

# *Overharvesting*

- Overharvesting is human harvesting of wild plants or animals at rates exceeding the ability of populations of those species to rebound
- Species with restricted habitats or large body size with low reproductive rates are especially vulnerable to overharvesting
  - For example, elephant populations declined because of harvesting for ivory
- Overfishing has decimated wild fish populations

# *Global Change*

- Global change includes alterations in climate, atmospheric chemistry, and broad ecological systems
- *Acid precipitation* is rain, snow, sleet, or fog with a pH <5.2
  - Acid precipitation contains sulfuric acid and nitric acid from the burning of wood and fossil fuels
  - Air pollution from one region can result in acid precipitation downwind
  - Acid precipitation kills fish and other lake-dwelling organisms

# Concept 43.2: Population conservation focuses on population size, genetic diversity, and critical habitat

- Biologists focusing on conservation at the population and species levels follow two main approaches
  - The small-population approach
  - The declining-population approach

# Small-Population Approach

- The small-population approach studies processes that can make small populations become extinct
- A small population is prone to inbreeding and genetic drift, which draw it down an **extinction vortex**
  - Causes small population to shrink until becoming extinct
- The key factor driving the extinction vortex is loss of the genetic variation necessary to enable evolutionary responses to environmental change

- **Minimum viable population (MVP)** is the minimum population size at which a species can survive
  - Depends on factors that affect a population's chances for survival over a particular time
- Genetic variation is the key issue in the small-population approach
  - Focus is on breeding individuals
- A meaningful estimate of MVP requires determining the **effective population size**
  - Based on the population's breeding potential
- Conservation programs attempt to sustain population sizes including a minimum number of reproductively active individuals to retain genetic diversity

# Declining-Population Approach

- The declining-population approach
  - Focuses on threatened and endangered populations that show a downward trend
    - Regardless of population size
  - Emphasizes the environmental factors that caused a population to decline in the first place

# Weighing Conflicting Demands

- Conserving species often requires resolving conflicts between habitat needs of endangered species and human demands
- The ecological role of the target species is an important consideration in conservation
  - Identifying keystone species and finding ways to sustain their populations can be central to maintaining communities and ecosystems

# Concept 43.3: Landscape and regional conservation help sustain biodiversity

- Conservation biology has attempted to sustain the biodiversity of entire communities, ecosystems, and landscapes
- Ecosystem management is part of landscape ecology
  - Seeks to make biodiversity conservation part of land-use planning

# Landscape Structure and Biodiversity

- The structure of a landscape can strongly influence biodiversity
- The boundaries, or edges, between ecosystems are defining features of landscapes
  - Some species take advantage of edge communities to access resources from both adjacent areas
- Landscapes dominated by fragmented habitats support fewer species due to a loss of species adapted to habitat interiors

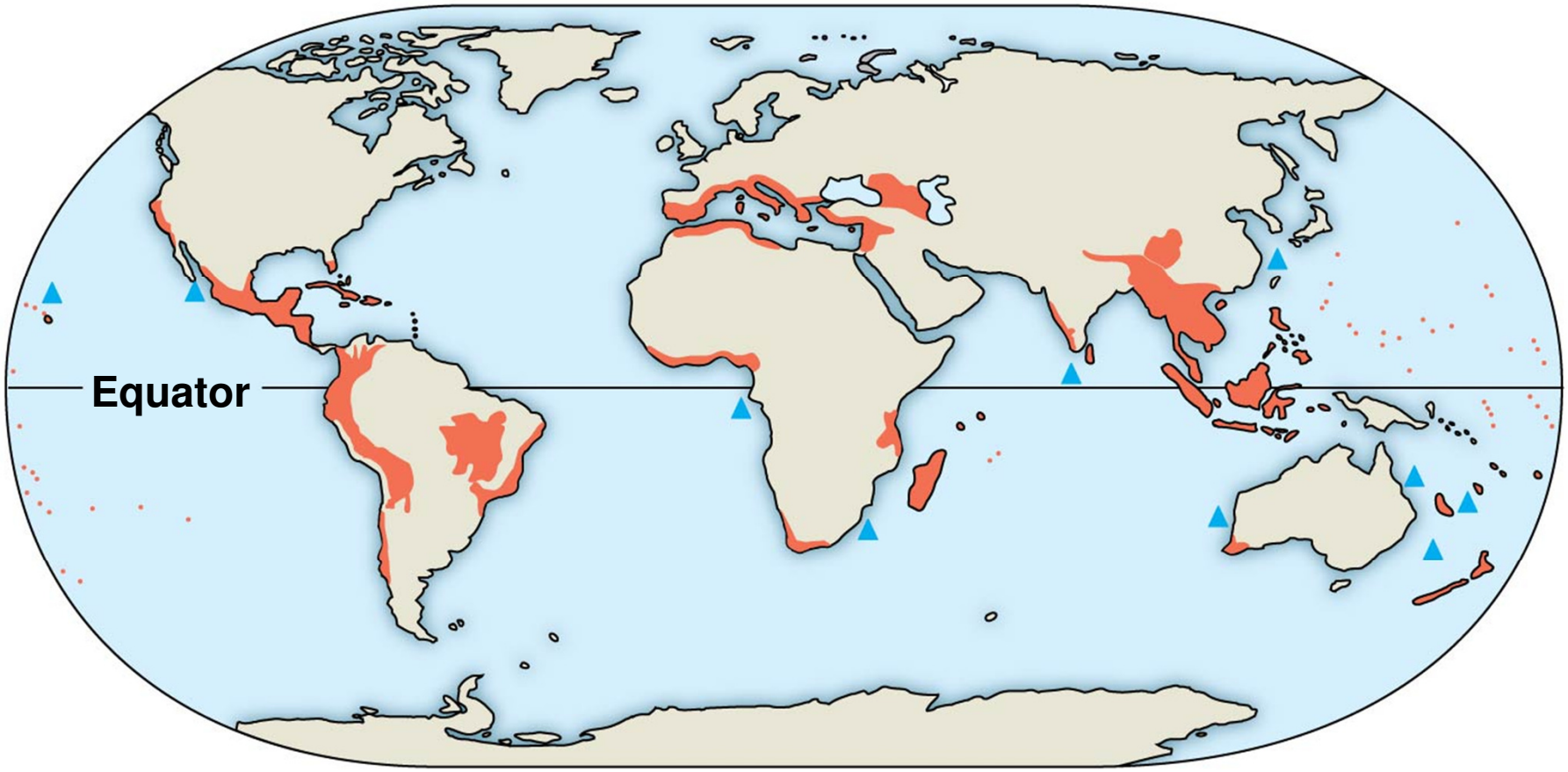
- A **movement corridor** is a narrow strip of habitat connecting otherwise isolated patches
  - Promote dispersal and reduce inbreeding
  - Can also have harmful effects
    - Ex: Promoting the spread of disease
- In areas of heavy human use, artificial corridors are sometimes constructed

# Establishing Protected Areas

- Conservation biologists apply understanding of landscape dynamics in establishing protected areas to slow the loss of biodiversity

- A **biodiversity hot spot** is a relatively small area with a great concentration of endemic species (species found nowhere else in the world ) and many endangered and threatened species
  - Good choices for nature reserves
  - Designation of hot spots is often biased toward saving vertebrates and plants
  - Hot spots can change with climate change

Figure 43.18




**Earth's terrestrial (■) and marine (▲) biodiversity hot spots**

- Nature reserves are biodiversity islands in a sea of habitat degraded by human activity
  - Must consider disturbances as a functional component of all ecosystems
- An important question is whether to create numerous small reserves or fewer large reserves
  - Smaller reserves
    - May be more realistic
    - May slow the spread of disease between populations
  - Large reserves
    - Have proportionally smaller perimeters, reducing edge effects
    - Large, far-ranging animals with low-density populations require extensive habitats

- A **zoned reserve** includes relatively undisturbed areas surrounded by human-modified areas of economic value
  - Creates buffer zones by regulating human activities in areas surrounding the protected core
  - Often established as “conservation areas”

Figure 43.20

Nicaragua
CARIBBEAN SEA
Costa Rica
Panama
PACIFIC OCEAN
National park land
Buffer zone

## Concept 43.4: Earth is changing rapidly as a result of human actions

- The locations of reserves today may be unsuitable for their species in the future
- Human-caused changes in the environment include
  - Nutrient enrichment
  - Accumulation of toxins
  - Climate change

# Nutrient Enrichment

- Humans transport nutrients from one part of the biosphere to another
  - Harvest of agricultural crops exports nutrients from the agricultural ecosystem
  - Agriculture leads to the depletion of nutrients in the soil
  - Fertilizers add nitrogen and other nutrients to the agricultural ecosystem

- **Critical load** is the amount of added nutrient that can be absorbed by plants without damaging ecosystem integrity
  - Nutrients that exceed the critical load leach into groundwater or run off into aquatic ecosystems
  - Agricultural runoff and sewage lead to phytoplankton blooms in the Atlantic Ocean
  - Decomposition of phytoplankton blooms causes “dead zones” due to low oxygen levels
    - EUTROPHICATION!

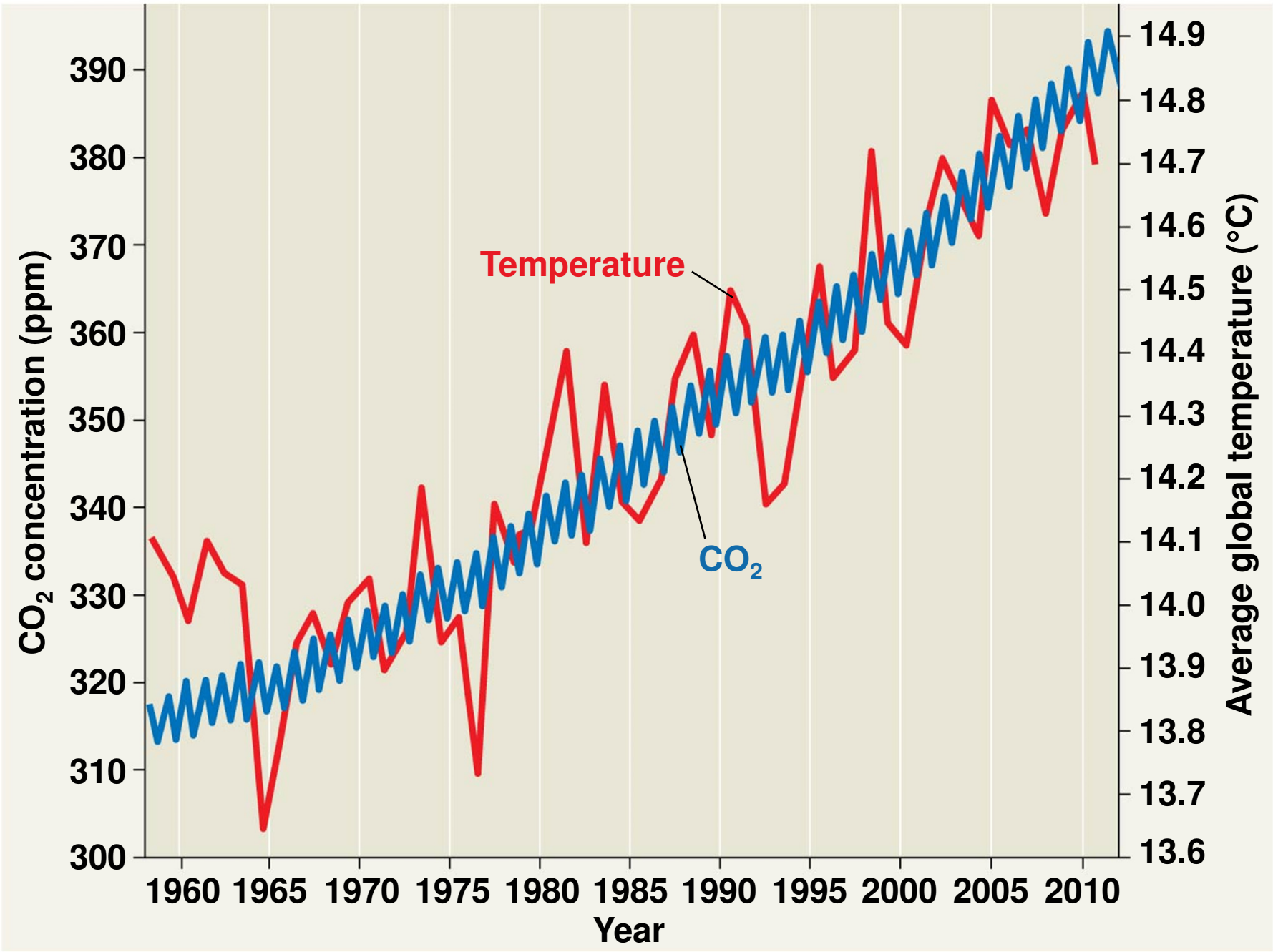
# Toxins in the Environment

- Humans release many toxic chemicals
- In some cases, harmful substances persist for long periods in an ecosystem
- One reason toxins are harmful is that they become more concentrated in successive trophic levels
  - **Biological magnification** concentrates toxins at higher trophic levels, where biomass is lower
    - Severely affects top-level carnivores

# Greenhouse Gases and Climate Change

- One pressing problem caused by human activities is the rising concentration of atmospheric $CO_2$ due to the burning of fossil fuels and deforestation
- $CO_2$, water vapor, and other greenhouse gases reflect infrared radiation back toward Earth
  - This is the **greenhouse effect**
    - Important for keeping Earth's surface at a habitable temperature!
    - But increasing concentration of atmospheric $CO_2$ is linked to increasing global temperature

Figure 43.26

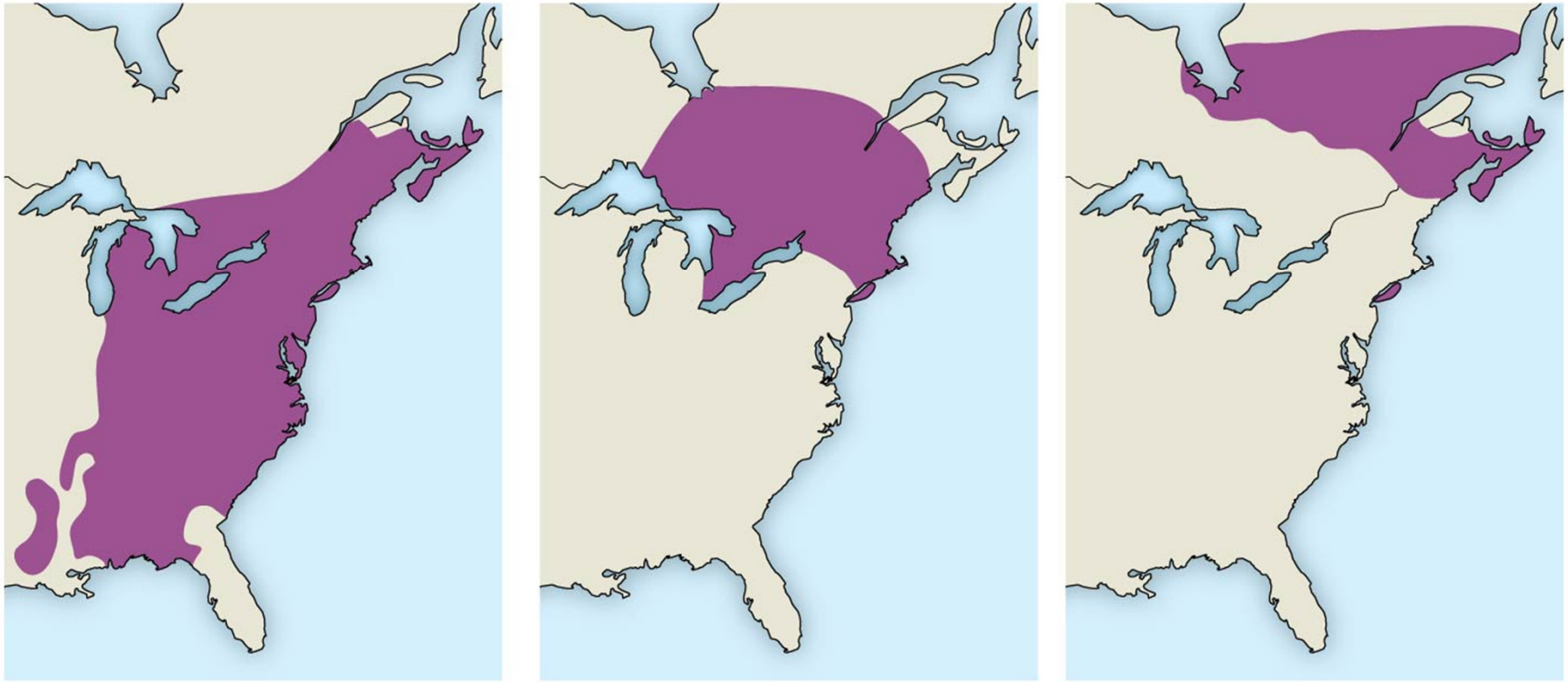

Temperature
$CO_2$
$CO_2$ concentration (ppm)
390
380
370
360
350
340
330
320
310
300
Average global temperature (°C)
14.9
14.8
14.7
14.6
14.5
14.4
14.3
14.2
14.1
14.0
13.9
13.8
13.7
13.6
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010
Year

- Climatologists can make inferences about prehistoric climates
  - $CO_2$ levels are inferred from bubbles trapped in glacial ice
  - Chemical isotope analysis is used to infer past temperature
- Northern coniferous forests and tundra show the strongest effects of global warming
  - In 2007, the extent of Arctic sea ice was the smallest on record
    - Decreasing habitat for polar bears, seal, and seabirds

# *Range Shifts and Climate Change*

- Many organisms, especially plants, may not be able to disperse rapidly enough to survive rapid climate change
- Many habitats today are more fragmented than ever
  - Limiting ability to migrate
- Researchers can track changes in tree distributions since the last period of glaciation to help infer future changes due to climatic warming
  - Use fossil pollen

Figure 43.27



**(a) Current range of American beech tree**

**(b) 4.5°C warming over next century**

**(c) 6.5°C warming over next century**

# *Climate Change Solutions*

- Global warming can be slowed by
  - Reducing energy needs
  - Converting to renewable sources of energy
    - Ex: Solar and wind power
  - Reducing deforestation would also decrease greenhouse gas emissions

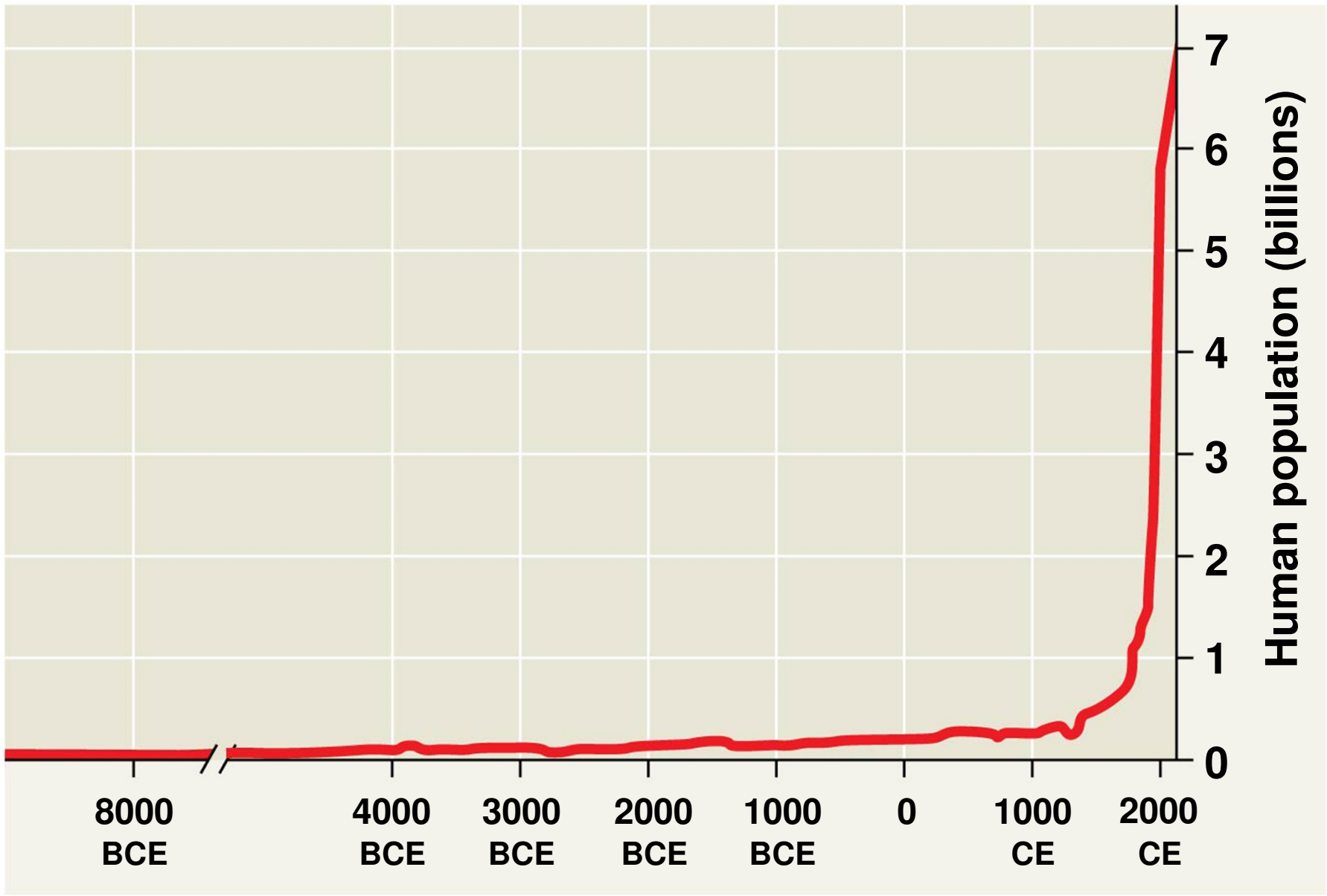
## Concept 43.5: The human population is no longer growing exponentially but is still increasing rapidly

- Global environmental problems arise from
  - Growing consumption of goods and resources
  - Increasing human population
- No population can grow indefinitely, and humans are no exception

# The Global Human Population

- The human population increased relatively slowly until about 1650 and then began to grow exponentially
  - The global population is now more than 7 billion
  - Though the global population is still growing, the rate of growth began to slow during the 1960s
- The growth rates of individual nations vary with their degree of industrialization
  - Most of the current global population growth is concentrated in developing countries
- Human population growth rates can be controlled through family planning, voluntary contraception, and increased access to education for females

Figure 43.28


Human population (billions)
0
1
2
3
4
5
6
7
8000 BCE
4000 BCE
3000 BCE
2000 BCE
1000 BCE
0
1000 CE
2000 CE

# Global Carrying Capacity

- The **ecological footprint** concept summarizes the aggregate land and water area needed to sustain the people of a nation
  - In terms of both resource production and waste absorption
  - It is one measure of how close we are to the carrying capacity of Earth

- Our carrying capacity could potentially be limited by food, space, nonrenewable resources, or buildup of wastes
  - Ex: Unstainable reliance on fossil fuels is changing Earth's climate and increasing amount of waste produced
- Unlike other organisms, we can regulate our population growth through social changes

## Concept 43.6: Sustainable development can improve human lives while conserving biodiversity

- The concept of sustainability helps ecologists establish long-term conservation priorities
- **Sustainable development** is development that meets the needs of people today without limiting the ability of future generations to meet their needs
- Fundamental indicators of living conditions are infant mortality rate, life expectancy, and literacy rate
  - In Costa Rica, living conditions have improved along with conservation

- Our appreciation of life guides the field of biology today
  - We celebrate life by deciphering the genetic code that makes each species unique
  - We embrace life by using fossils and DNA to chronicle evolution through time
  - We preserve life through our efforts to classify and protect the millions of species on Earth
  - We respect life by using nature responsibly and reverently to improve human welfare
- We are most likely to protect what we appreciate, and we are most likely to appreciate what we understand!